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Application of tabu search and genetic algorithm in minimize losses in power system. Using the b-coefficient method

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Abstract

This paper presents a new approach to the use of loss minimization by proposing the incorporation of the *B-coefficient* method. In this way the choice of control settings can be determined whilst minimizing losses. It is believed that this technique will be of particular advantage to industrial. The causes, types and effects of losses are first described. Then follow an extract from a real life load flow study to illustrate present usage. A modified technique of loss minimization is then proposed using modified B-losses coefficients. With a view to arriving at a load flow suited to an industrial application. The application of optimization techniques to power system planning and operation problems has been an area of active research in the recent past. In this paper we used, the tabu search algorithm (TS) and the genetic algorithm (GA) to minimize the losses in power system. An IEEE 14-bus power system has been used to test the proposed method.

Keywords: power system, losses minimization, metaheuristic, tabu serach, genetic algorithm, B-coefficient method.

1. Introduction

The quantification and minimization of losses is important because it can to a more economic operation of a power system. If we know how the losses occur, we can take steps to limit the losses.

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Hence, if more losses can be minimized, the power can be consumed efficiently. Existing power generation and transmission can be used effectively without having to build new installation and at the same time save the cost of losses [1,2].
Losses result from current flow in resistive materials and magnetizing energy in transformers and motors.
This paper presents the B-coefficient method to minimize the losses in power system. We presented this problem by the tabu serach (TS) and genetic algorithm (GA).

Nomenclature

A	radius of
B	position of
C	further nomenclature continues down the page inside the text box

2. Losses in Power Systems

To determine *B-loss coefficients*, it is necessary to determine the precise loss mechanisms, which occur in the system. Traditionally, *B-loss coefficients* have been applied to transmission line analysis where the losses are predominant by only line loss determined by I^2R. Transformer losses are not significant in such systems. The only other losses are corona, which will occur only under foul weather conditions. However, in industrial power systems, the losses are more diverse and thus *B-loss coefficients* will be more complicated to utilize [1,3].
Considered a simple three-phase radial transmission line between two points of generating /source and receiving/load as illustrated by Figure 1.

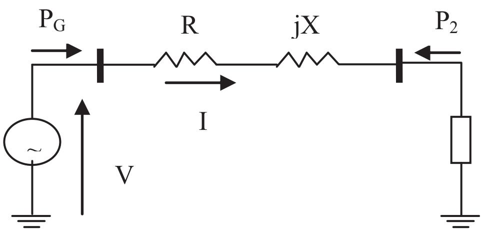

Fig.1.Radial line with one generation and one load.

We can deduce that the line loss is:

$$P_{loss} = 3I^2R \qquad (1)$$

Where:
R is the resistance of the line in ohms per phase. The current *I* can be obtained:

$$|I| = \frac{P_G}{(\sqrt{3})V_G \cos\varphi_G} \qquad (2)$$

P_G is the generated power (load power and losses);

V_G is the magnitude of the generated voltage (line-to-line), cos φ_G is the generator power factor. Combining the above two equations, we have:

$$P_L = \frac{R}{|V_G|^2 \cos^2 \varphi_G} (P_G^2) \tag{3}$$

Assuming fixed generator voltage and power factor, we can writhe the losses are:

$$P_L = BP_G^2 \tag{4}$$

Where in this case

$$B = \frac{R}{|V_G|^2 \cos^2 \varphi_G} \tag{5}$$

Losses are thus approximated as a second order function of generation. If a second power generation is present to supply the load as shown in figure 2, we can express the transmission losses as a function of the two plant loadings [4, 5].

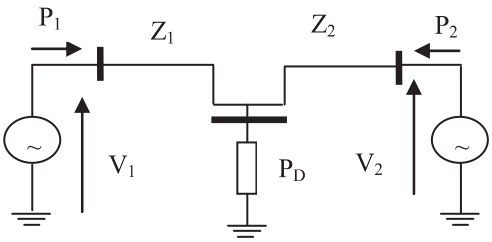

Fig.2. Radial system with one additional generation to load.bus.

Losses can now be expressed by the equation (Minimize the objective function):

$$P_L = P_1^2 B_{11} + 2P_1P_2B_{12} + P_2^2 B_{22} \tag{6}$$

Subjected to the constraints:
-Power balance (equality constraints)

$$P_1 + P_2 - P_L - P_D = 0 \tag{7}$$

-Threshold limits (inequality constraints)

$$P_i^{min} < P_i < P_i^{max} \tag{8}$$

Where P_i^{min} and P_i^{max} are the minimum and maximum power generation limits.

3. Genetic Algorithm

Genetic algorithm (GA) are search algorithm based of natural selection and natural genetics [6]. The law of coincidence takes advantage of preinformation in order to derive improvement from it.
GA are algorithm for optimization based on the principle of biological evolution. They are unlike many conventional search algorithms in the sense that they simultaneously consider many points in the search space. They work not with the parameters themselves but with string of numbers representing the

parameter set. And they are probabilistic rules to guide their search. By considering many points in the search space simultaneously reduce the chance of converging to local minima. The process of GA follows this pattern [7].

1. An initial population of random solution is created.
2. Each member of the population is assigned a fitness value based on its evaluation against the current problem.
3. Solution with high fitness value is most likely to parent new solutions during reproduction.
4. The new solution set replaces the old, a generation is completed and the process continues at step (2).

The algorithm improves each individual solution by combining and transferring the beneficial characteristics of highly parents to their off spring. Members of the population are represented as bit strings, which are improved repeatedly with a series of genetic operators, known as reproduction, crossover and mutation. This simple genetic procedure consistently produces even fitter offspring through successive generations, which gradually leads the search towards the optimal point.
When this genetic approach is reflected in computing language, it involves nothing more than string copying and partial string exchanging, yet it can attain good results in circumstances which are resistant to known methods. The simplicity of the computational procedure and the powerful search ability of GA have attracted wide attention in various engineering field, such as function optimization, gas pipe control, game playing pattern recognition and electric power scheduling [6]. The further attraction is that they are extremely robust with respect to complexity of the problem.

4. Tabu Search

Tabu search (TS) is a metaheuristic that is used to manage a local method to search the solution space without entrapping into a local optimum by means of some strategies. The term “Tabu Search” first appeared in literatures in Glover’s paper (1986) [8]. Hansen (1986) [9] brought up a similar idea and called it “the steepest ascent/mildest descent heuristic”.

Tabu search is an iterative search method. It uses a local search algorithm at each iteration to search for the best solution in some subset of the neighborhood, which came from the best solution obtained at the last iteration. At each iteration, the local search algorithm looks for the best improving solution. If all solutions are not improving the objective function value, then it looks for the least deterioration solution. Tabu search keeps a list, which is called tabu list, of the moves it used to obtain the best solutions during each iteration and to restrict the local search algorithm in reusing those moves. A memory is used to keep track of this tabu list. Usually the tabu list has a pre-specified length. Therefore, this list varies from iterations to iterations.
There are mainly three strategies employed in tabu search: the forbidding strategy, the freeing strategy and the short-term strategy. The foebidding strategy what enters the tabu list. The freeing strategy decides what exits the tabu list and when the exit will occur. The short-term strategy manages the interplay between the forbidding strategy and freeing strategy to generate and select trial solutions [10].

The outline of Tabu search algorithm is described as follows:
Step 1: Choose an initial solution “x” in S. Set x*=x and k=0.
Step 2: Set k=k+1 and generate a subset V* of solution in N(x, k) sush that either one of the Tabu conditions is violated or at least one of the aspiration conditions holds.

Step 3: Choose a best j in V* and set x=j.
Step 4: If f(x) < f(x*) then set x*=x.
Step 5: Update Tabu and aspiration conditions.
Step 6: If a stopping condition is met then stop. Else go to Step 2.
Where
(x, j) solution indexes ; k: iteration index; V*: subset of solution; N(x, j): neighborhood of solution x at iteration k; f(x) objective function value for solution x.

5. Numerical Results

The IEEE 14-bus power system has been tested using MATLAB-R12 on PC-Pentium 2 GHz. The IEEE 14-bus power system [11] consists of 2 generator buses, 13 load buses, and 20 branches. The fuel cost in ($/hr) equations for the generator are:

$F_1 (P_{G1}) = 0.006\, P_{G1}^2 + 1.5\, P_{G1} + 100$
$F_2 (P_{G2}) = 0.009\, P_{G2}^2 + 2.1\, P_{G2} + 130$

And the constraints are: (the unit operating ranges in MW):

$135 \leq P_{G1} \leq 195;$
$70 \leq P_{G2} \leq 145;$

The total load was 259 MW

5.1. Parameters values for GA

The parameters values for GA have a number of population size, crossover and mutation probability, chromosomes length and number of generations [12]:

- Population size: 30;
- Crossover probability: 0.75;
- Mutation probability :0.006
- Chromosomes length: 12;
- Number of generations: 300.

5.2. Parameters values of TS

The parameters values of TS have a tabu list length, Number of neighborhood, Number of diversification and number of generations:

- Tabu list length:10;
- Number of neighborhood:45;
- Number of diversification :1;
- Number of generations: 200.

The parameters of B-coefficients are:

B11=0.0319; B22=0.0305; B12=0.0125

$$P_L = 0.0319 P_{G1}^2 + 0.0305 P_{G2}^2 + 0.025 P_{G1} P_{G2} \tag{9}$$

$$P_{G1} + P_{G2} - 0.0319P_{G1}^2 - 0.0305P_{G2}^2 - 0.025P_{G1}P_{G2} - 250 = 0\ (MW) \tag{10}$$

The minimum cost and active power are presented in table 1:

Table 1. Result of GA, TS

	TS	GA
P_{G1}^{opt} (MW)	185.5055	189.3736
P_{G1}^{opt} (MW)	90.3114	88.2234
Cost ($/hr)	977.7960	984.5586
P_L(MW)	16.82	18.60
Time (s)	1.11	1.84

6. Discussion of the results

This article helped us to familiarize ourselves with the area of optimization applied in power systems and the calculation of the flow of charges. Indeed, we have studied and applied two methods to the optimal distribution of active power loss minimization and active using the B-coefficient method.

The application of metaheuristic methods mentioned above on an IEEE-14 bus we concluded that tabu search is giving good results on the one hand the optimal cost and other operating losses compared to the genetic algorithm. Computation time using tabu search is lower compared to what it determined by the genetic algorithm

7. Conclusion

In this paper we apply two methods in the field of metaheuristics power systems one is based on a population of chromosomes called genetic algorithms, the other is based on an initial point called tabu search.

Our goal is to optimize the cost of production of electrical energy and minimize losses in the active lines using the method of B-Coefficients. Application of two methods has led us to a remarkable comparison is clear, is that good or tabu search seeks the optimum faster than genetic algorithms in a shorter time, it is because genetic algorithms are rather slow. The B-coefficient methods has facilitated the calculation, so the application of the latter in this article we enriched us knowledge by calculating the active losses are not constant.

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Appendix

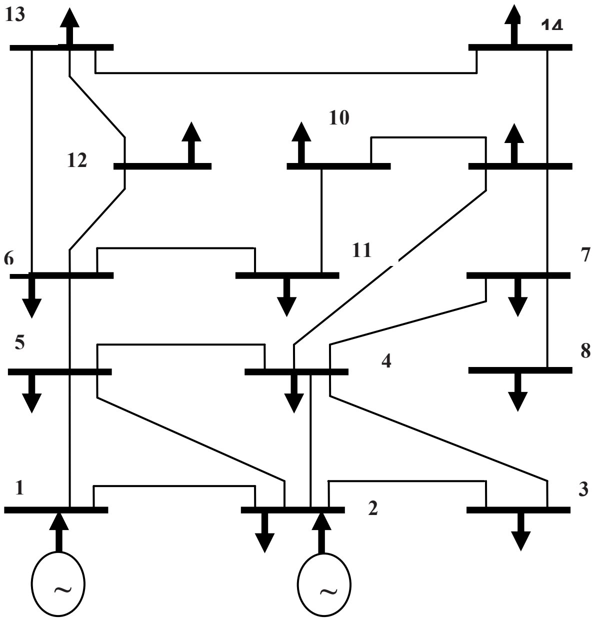

Fig.3 IEEE 14-bus

k-m	impedance	shunt admittance
1-2	0.01938+j0.05917	j0.0264
1-5	0.05403+j0.22304	j0.0246
2-3	0.04699+j0.19797	j0.0219
2-4	0.05811+j0.17632	j0.0187
2-5	0.05695+j0.17388	j0.0170
3-4	0.06701+j0.17103	j0.0173
4-5	0.01335+j0.04211	j0.0064
4-7	0.00000+j0.02091	j0.0000
4-9	0.00000+j0.55618	j0.0000
5-6	0.00000+j0.25202	j0.0000
6-11	0.09498+j0.19890	j0.0000
6-12	0.12291+j0.25581	j0.0000
6-13	0.06615+j0.13027	j0.0000
7-8	0.00000+j0.17615	j0.0000
7-8	0.00000+j0.11001	j0.0000
9-10	0.03181+j0.08450	j0.0000
9-14	0.12711+j0.27038	j0.0000
10-11	0.08205+j0.19207	j0.0000
12-13	0.22092+j0.19988	j0.0000
13-14	0.17093+j0.34802	j0.0000

Fig.4. input data IEEE14-bus.